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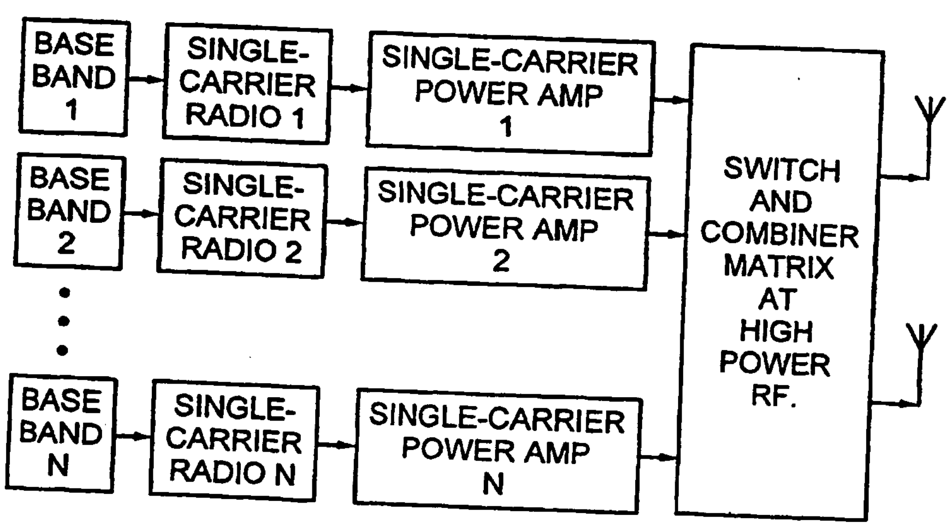


(57) Abstract

A radio transceiver station avoids the problems of prior devices that either do not use multi-beam antennas or use multi-carrier power amplifiers, permitting signals from several transceivers to be selectively directed to one antenna lobe with low loss. The radio transceiver station includes an antenna system having a plurality of beams, a plurality of radio transmitters, each radio transmitter including a base band part and a radio frequency part having a single-carrier radio frequency power amplifier, a plurality of filters that are respectively connected to the plurality of radio transmitters and that are tunable to respective carrier signals generated by respective radio transmitters, and a switch matrix for connecting selected ones of the filters to the antenna system such that carrier signals generated by the transmitters and amplified by the single-carrier radio frequency power amplifiers can be radiated through selected beams. Each transmitter can be connected to each antenna beam independently of each other transmitter.

MULTI-TRANSMITTER SYSTEM

BACKGROUND

This invention relates generally to electrical communication and particularly to cellular radio communication.

Modern communication systems, such as cellular and satellite radio telephone systems, employ various modes of operation (analog, digital, and hybrids) and access techniques such as frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), and hybrids of these techniques.

In North America, a digital cellular radiotelephone system using TDMA is called the digital advanced mobile phone service (D-AMPS), some of the characteristics of which are specified in the TIA/EIA/IS-136 standard published by the Telecommunications Industry Association and Electronic Industries Association (TIA/EIA). Another digital communication system using direct-sequence CDMA is specified by the TIA/EIA/IS-95 standard, and a frequency-hopping CDMA communication system is specified by the EIA SP 3389 standard (PCS 1900). The PCS 1900 standard is an implementation of the Global System for Mobile communication (GSM) that is common outside North America and that has been introduced in North America for personal communication services (PCS) systems.

In these communication systems, communication channels are implemented by frequency modulating radio carrier signals, which have frequencies near 800 megahertz (MHz), 900 MHz, 1800 MHz, and/or 1900 MHz. In TDMA systems and even to varying extents in CDMA systems, each radio channel is divided into a series of time slots, each of which contains a block of information for a user. The time slots are grouped into successive frames that each have a predetermined duration, and successive frames may be grouped into a succession of what are usually called superframes. The kind of access technique (e.g., TDMA or CDMA) used by a communication system affects how user information is represented in the slots and frames, but current access techniques all use a slot/frame structure.

Efforts to create better antenna systems for these cellular radio communication systems are getting more and more attention. In particular, multi-lobe antennas are frequently mentioned as the next revolution of cell planning, and examples of systems using such antennas are being developed for GSM systems and wideband CDMA

systems. Some reasons for using multi-lobe antennas will become apparent from the following discussion.

FIG. 1 depicts an example of a conventional cellular radio communication system 100, which includes a plurality of radio base stations (RBSs) 170a-170n connected to a plurality of corresponding antennas 130a-130n. The radio coverages of the RBS/antenna combinations are depicted by corresponding cells 110a-110n, which are illustrated as hexagons merely for convenience. The RBSs 170a-170n, in conjunction with the antennas 130a-130n, communicate with a plurality of remote terminals (RTs) 120a-120m (e.g., mobile stations) located in the cells 110a-110n. The communication link for signals sent from a RBS to a RT is usually called the downlink, and the communication link for signals sent from a RT to a RBS is usually referred to as the uplink.

The RBSs 170a-170n are connected to a mobile telephone switching office (MTSO) 150, which among other tasks coordinates the activities of the RBSs, such as during a handoff of a communication link from one RBS or cell to another. The MTSO can be connected to another communication network, such as a public switched telephone network 160 that serves users through various communication devices like a telephone 180a, a computer 180b, and a facsimile machine 180c.

A typical GSM-type communication system is depicted in more detail in FIG. 2. Each RBS 170 typically handles a plurality of control and traffic channels, which may carry voice, facsimile, video, and other information, through a plurality of transceivers (TRXs) 172 that are monitored by a controller 174. Each TRX 172 may be considered as having a baseband part 176 that, for the downlink, receives information signal frames from a base station controller (BSC) 140 and a radio frequency (RF) part 178 that appropriately modulates a RF carrier signal with portions (e.g., a slot or slots) of the information signal frames. Also shown in the exemplary cellular communication system of FIG. 2 is a RT 120 that includes a transceiver 122 for communicating with the RBSs on the traffic and control channels and a processor 124 for controlling operation of the RT.

The TRXs send and receive signals through the antenna 130, which is shown connected separately to individual TRXs simply for convenience of explanation. Since a GSM system can use different carriers for different portions (e.g., slots, or bursts) in each information signal frame directed to a particular RT, the RF part of each TRX may implement carrier frequency hopping. The BSC, which typically controls a plurality of

RBSs, "knows" how many TRXs there are in each RBS and allocates a number of carriers (e.g., eight) to each TRX. Thus, information signal frames or bursts received by the BSC from the MTSO 150 can be directed to particular TRXs 172 in particular RBSs 170 based on information elements included in the signal frames; it is left to the RBS to handle distribution of the frames and the carrier-frequency-hopping slots to the appropriate TRXs. Each base band part 176 includes a processor that checks the information received from the BSC, and based on an indication of the carrier desired for each slot, the appropriate base band part passes the slot information to its associated RF part 178 for transmission to a particular RT.

The TRX handling the control channel broadcasts control messages (such as call- or session-setup messages exchanged by RBSs and RTs and synchronization messages used by RTs for synchronizing their transceivers to the frame/slot/bit structures of the RBSs) to RTs locked to that control channel. It will be understood that the TRXs 172 can be implemented as a unitary device for control and traffic channels that share the same carrier signal.

The downlink in a given cell can be degraded by signals transmitted by other RBSs or transmitters operating in the same frequency band. A frequency re-use plan can mitigate such interference by locating potentially interfering cells as far from each other as possible. Transmission power control can also reduce interference by ensuring that transmitters use the minimal power needed for adequate communication.

Interference can be reduced still further by using a plurality of narrow-beam antennas to communicate with terminals in a cell. A narrow-beam antenna exchanges signals with a respective, limited geographic portion of the cell, thereby reducing the interference experienced by terminals outside that portion. Today's communication systems typically are partitioned either into three 120°-sectors, each serviced by a respective one of three sector antennas, or into six 60°-sectors, each serviced by a respective one of six sector antennas. It will be understood that even smaller "sectors" can be realized by a phased array antenna having a plurality of narrow beams that may be fixed or independently steered.

FIG. 3, for instance, illustrates a cell in a communication system 200 that has a RBS 220 employing an antenna (not shown) having a plurality of narrow beams (B_1, B_2, B_3, B_4, etc.) that extend radially from the RBS 220. Preferably, the beams overlap to cover the cell completely. Although not shown, the antenna may include three separate phased array sector antennas, each of which communicates with a 120°

swath extending from the RBS 220. FIG. 3 also shows a RT 210 located within the beam B_1, and communication proceeds between the RBS 220 and the terminal 210 using the beam B_1, or perhaps in addition, one or more adjacent beams.

In such communication systems, signals can be selectively transmitted and received in particular directions by narrow-beam (high-gain) antennas, decreasing the interference experienced by the terminals. This results in an improvement in a communication link's carrier-to-interference (C/I) ratio and an increased system capacity. For example, as described in Garg et al., Applications of CDMA in Wireless/Personal Communications, pp. 332-334, Prentice Hall (1997), an idealized eight-beam antenna might provide a three-fold increase in capacity over some cell-sectorization schemes.

In general, use of a multi-lobe antenna for an application like a RBS in a cellular telephone system implies use of at least one multi-carrier power amplifier (MCPA), which is a device for amplifying an RF signal consisting of a plurality of distinct carrier signals. Two main approaches to a RBS using MCPAs can be understood from FIGS. 4A and 4B.

FIG. 4A depicts a RBS that reflects what might be called a MCR/MCPA approach. Digital signals produced by a plurality of base band units (i.e., signals just before digital to analog (D/A) conversion) that are intended for the same antenna beam are summed and processed by a common wide-dynamic-range D/A converter. As indicated in FIG. 4A, digital signals produced by base band parts 1, 2, 3 are summed in a multi-carrier radio (MCR) 1 and a MCR2. The name "multi-carrier radio" or MCR derives from the fact that all following analog components, such as the modulator, filters, and RF amplifiers, are common for the combined signals. The resulting signal produced by each MCR is then typically amplified, by an MCPA in FIG. 4A. Each base band unit chooses which antenna beam to transmit on, and sends its digital signal to the corresponding MCR. Since many base band units can simultaneously transmit on the same antenna beam, the radio and the power amplifier must be multi-carrier ones, with one MCR and one MCPA for each antenna as indicated in FIG. 4A.

FIG. 4B depicts a RBS that reflects what might be called a SCR/MCPA approach. Rather than combining signals digitally at base band as in the MCR/MCPA approach, each base band unit is handled by a separate radio (hence the name "single carrier radio" or SCR), and the separate modulated carrier signals are switched and combined at low RF power. Final amplification to a power level suitable for

transmission requires one MCPA for each antenna beam. In this approach, switching and combining are usually done using hybrid combiners since their losses are acceptable because they occur before the final amplification.

Nevertheless, as the number of antenna beams and the number of signals to be combined increases, the complexity and physical size of the switching and combining network increases. Indeed, a system having eight base band units and eight antenna lobes might have as many as sixty-four RF switches and fifty-six hybrid combiners. European Patent Publication EP 0 593 822 to Searle et al. describes a base station antenna arrangement that has a plurality of antenna arrays, beam-forming devices, and transceivers, with a switching matrix for connecting each transceiver with one or another of the antenna arrays via the beam-forming devices. This system employs a plurality of hybrid combiners and then a multi-carrier power amplifier. Another system is described in U.S. Patent No. 5,048,116 to Schaeffer that describes a signal routing system for use with eight transmitters and a plurality of frequency responsive devices. Schaeffer's arrangement requires a large number, sixty-four, of such frequency responsive devices, making the system physically large and difficult to scale up. European Patent Publication EP 0 439 939 to Davis describes a signal divider/combiner array that divides/combines antennas among a plurality of transceivers. The divider/combiner array includes a plurality of controllable switches.

It is desirable for a RBS to be compatible with the other components of today's typical cellular communication systems and to require no or minimal modification of those components. One aspect of such compatibility is that the RBS should not require any modification of the system that decides which transceiver to use for communicating with a remote terminal. Thus from the point of view of the BSC or MTSO, the RBSs should look substantially alike. If the BSC is to be unaware of the internal structure of the RBS, each transceiver in the RBS must be able to communicate with every remote terminal in the cell. Also, all remote terminals in a cell may be in the same area, i.e, in the same antenna lobe, and thus each transceiver must be able to transmit in each antenna lobe.

While systems depicted in FIGS. 4A, 4B or described in the documents cited above may be capable of connecting different transceivers to different antenna lobes, these systems have a number of disadvantages. An important typical disadvantage is the physical volume needed to accommodate the large number of switches and hybrid combiners. Another important disadvantage is the relative inefficiency of the multi-

carrier power amplifiers compared to single-carrier power amplifiers. In fact, the typical electrical efficiency of a multi-carrier RF power amplifier may be only about three percent (e.g., a hundred watts of electrical power in produces only about three watts of RF power out), which is markedly lower than the approximately thirty per cent electrical efficiency typical of a single-carrier power amplifier.

Also important is the loss through the switching and combining network, a loss that can be greater than 10 dB. Part of this loss may be recovered by using an antenna having higher gain than the antennas usually used in cellular systems, but it is common for such systems still to have poor link budgets. This might be acceptable in some environments, such as high density networks of geographically small cells, but in general it is desirable to use a multi-lobed antenna system to enable bigger cells.

SUMMARY

Applicant's invention satisfies the desire for a RBS that is compatible with the other components of a typical cellular communication system, and can easily be implemented in current RBSs, such as the RE 2000 family of devices available from Ericsson Radio Systems AB. Moreover, Applicant's invention provides a RBS that avoids the problems of prior devices that either do not use multi-beam antennas or use multi-carrier power amplifiers. In one useful embodiment of Applicant's invention, signals from six transceivers can be selectively directed to one antenna lobe with only about 3.5-dB loss.

In accordance with one aspect of Applicant's invention, a radio transceiver station includes an antenna system having a plurality of beams, a plurality of radio transmitters, each radio transmitter including a base band part and a radio frequency part having a single-carrier radio frequency power amplifier, a plurality of filters that are respectively connected to the plurality of radio transmitters and that are tunable to respective carrier signals generated by respective radio transmitters, and a switch matrix for connecting selected ones of the filters to the antenna system such that carrier signals generated by the transmitters and amplified by the single-carrier radio frequency power amplifiers can be radiated through selected beams. Each transmitter can be connected to each antenna beam independently of each other transmitter.

In other aspects of the invention, the selected filters are connected to the antenna systems according to switch control signals based on information elements in information signal frames to be transmitted, the tunable filters include at least one

tunable resonant cavity, and the switch matrix comprises a plurality of p-i-n diodes. The radio transceiver station may further include a signal bus connected between the base band parts of the radio transmitters for selectively distributing information signal frames to the radio frequency parts of the radio transmitters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a conventional cellular radio communication system;

FIG. 2 illustrates a radio base station and a remote terminal;

FIG. 3 illustrates a radio base station having a multi-lobed antenna;

FIGS. 4A, 4B illustrate two approaches to switching and combining signals in a radio base station;

FIGS. 5A, 5B illustrate a radio base station in accordance with Applicant's invention; and

FIGS. 6A, 6B illustrate switch matrices for a radio base station in accordance with Applicant's invention.

DETAILED DESCRIPTION

This application describes the invention in a context of a cellular radio communication system, but it will be understood that this is just an example and that the invention can be applied in many other contexts.

As may be known, combining a plurality of RF carrier signals and providing the combined signal to one antenna or antenna beam can be achieved using either hybrid combiners or tunable cavities. In accordance with one aspect of Applicant's invention, signal combining is accomplished with tunable cavities rather than hybrid combiners because it is desirable to minimize losses in order to maximize range. In another aspect of the invention, the antenna lobe is selected after the tunable cavities, and in yet another aspect, single-carrier power amplifiers can be used in the transceivers. These aspects can be seen in the system illustrated in overview by FIG. 5A and in detail by FIG. 5B.

Referring to FIG. 5A, a plurality of base band parts 1, 2, . . . , N feed respective SCRs 1, 2, . . . , N and SCPAs 1, 2, . . . , N. The high-RF-power outputs of the SCPAs are provided to a switch and combiner matrix that directs the proper signals to the proper antennas or antenna beams, only two of which are indicated in FIG. 5A. Since switching and combining is carried out with high-power RF signals, SCPAs can be

used rather than inefficient MCPAs. An important aspect of Applicant's invention is a switching and combining matrix that minimizes losses.

FIG. 5B shows the RF parts 11-14 of four transceivers that are coupled to respective tunable cavities TC11-TC14. The RF parts correspond to the SCRs depicted in FIG. 5A. Additional transceivers may be provided but are not shown in FIG. 5B for clarity. Signals passed by the tunable cavities are provided to a switch matrix SM, only two portions A, B of which are shown in FIG. 5B for clarity. The switch matrix connects signals from selected ones of the tunable cavities to respective ones of several antennas or antenna lobes. In FIG. 5B, only two antennas ANT11, ANT12 are shown for clarity. It will be understood that Applicant's invention can be embodied in systems having more or fewer transceivers and/or antennas.

The tunable cavities TC may be conventional, selected as appropriate for the signal frequencies used. For some GSM cellular telephone systems, carrier signals are separated by about 800 KHz at about 900 MHz. It is only necessary that the tunable cavities have bandwidths suitable for sufficiently isolating one carrier from another. Applicant has found that an isolation of about 10 dB currently seems to be sufficient. If the cavities are tunable slowly, e.g., on the order of a few seconds, the cavities would typically be pre-tuned to the carriers used by the RBS. Since the RBS would be more flexible if it could change carriers more rapidly, say on the order of microseconds (a fraction of a slot duration), it is desirable for the cavities to be more quickly tunable, but this is not necessary.

In one aspect of Applicant's invention, the transceivers are interconnected by a bi-directional signal bus Xbus that distributes information signal frames or portions of those frames among the transceivers. In the embodiment illustrated in FIG. 5B, the Xbus is disposed between the base band parts (not shown in FIG. 5B) and the RF parts of the transceivers. In this way, bursts or frames that call for transmission by a particular carrier can be provided to the appropriate RF part and tunable cavity TC, without requiring on-the-fly tuning. The information distributed by the Xbus preferably includes the information signal frames from the BSC and may include other appropriate messages, e.g., an information element or elements identifying the antenna lobe to be used for the burst(s) or frame(s). The base band units may also "know" which antenna lobes to use for communicating with particular remote terminals based on well known beam selection techniques, many of which use information derived by the receiving parts of the transceivers from signals received from the remote stations.

It will be appreciated that the distribution of the information signal frames or bursts may be carried out in other ways and still be within the scope of Applicant's invention. For example, it is not necessary for an RBS to use a signal bus Xbus for distributing the frames. In such an embodiment, the BSC would provide the frames to a controller that would distribute the frames or portions of frames to the appropriate transceivers (i.e., to the appropriate base band parts).

Based on the information signal frames and Xbus information, the proper RF part causes the switch matrix SM to set its switches so that the signal can be transmitted through the chosen antenna lobe. This arrangement enables carrier-frequency hopping by suitably distributing information at base band, and is compatible with currently available RBSs.

The switch matrix SM is set so that the proper antennas or antenna lobes are connected to which RF parts of the transceivers in accordance with switch control signals provided by the RF parts of the transceivers. It will be recognized that the switch control signals generated by the RF parts can be based on information in the information signal frames arriving from the BSC and/or on the Xbus information. The particular form of these control signals is not critical; it is only necessary that they operate the switch matrix SM in a suitable manner. With the distribution of signals by the Xbus, each transceiver-to-antenna connection is made independent of other such connections in this way. It will be appreciated that although FIG. 5B indicates an arrangement of eight transceivers and eight antennas, the numbers of transceivers and antennas are easily independently scalable. It will be understood that the more antennas or antenna beams there are in a system, the narrower each beam is, but also the larger the physical size of the base station becomes.

The switch matrix SM preferably comprises a plurality of p-i-n diode switches connected in a manner that permits any antenna lobe to be connected to any transceiver according to the switch control signals from the RF parts. By using p-i-n diodes as switches, the selection of antenna port for a transmitter can be changed rapidly, even on a slot-by-slot (a microsecond timescale) basis. It will be appreciated, however, that devices other than p-i-n diodes, such as transistors (e.g., FETs), can be used in the switch matrix SM.

FIG. 6A depicts switches A1, A2 that are part of portion A of the switch matrix SM and switches B1, B2 that are part of portion B of the switch matrix SM. FIG. 6A is based on an assumption that the tunable cavities TC have adequately high RF

impedances at frequencies other than the frequencies to which they are tuned. In case of an open switch, both sides of the switch should have high impedance (open circuit). The switches are configured to ground (short) the connections, with the result that the switches do not handle the high RF power from the transceivers. The switches and conductors between the antennas and tunable cavities are preferably implemented on a single substrate, such as a printed circuit board (PCB), to minimize the effects of conductor tolerances and to maximize performance.

By setting their switch control signals so that both switches A1, A2 are closed, the RF parts 11, 12 may both be connected to the same antenna (antenna A in FIG. 6A), enabling simultaneous transmission of different carriers through the same antenna or antenna lobe. The other paths through the switch matrix have high impedances due to the open switches B1, B2, and the length-$\lambda/2$ conductors, where λ is the RF signal's wavelength in the conductor. By closing the switches A1, B2, the transceiver TRX11 transmits alone on antenna A and the transceiver TRX12 transmits alone on antenna B. It should be noted that other combinations of switch characteristics and conductor lengths can give the same kind of functionality.

FIG. 6B illustrates an embodiment using p-i-n diodes as the switches in the switch matrix SM that corresponds to the more general structure depicted in FIG. 6A. There is one control signal for each pin-diode switch, only four of which are shown, with a positive control signal causing the p-i-n diode to enter a high RF impedance state and a negative control signal causing the p-i-n diode to enter a low RF impedance state. As in FIG. 6A, the tunable cavity filters, only two of which (TC11, TC12) are shown, are assumed to have high RF impedance at frequencies other than the ones they are tuned to. Seen from the output of a tunable cavity filter, a low RF impedance state of a p-i-n diode is seen as a high RF impedance due to the quarter-wavelength transformer. To direct the RF signal from the RF part 12 to the antenna B, the switch A2 should have a low RF impedance and the switch B2 should have a high RF impedance. If more than one transmitter is transmitting on the same antenna, the high RF impedances of the tunable cavity filters for frequencies other than the ones they are tuned to makes the RF signals combine in the antenna. If the RF part 11 is transmitting on antenna A and the RF part 12 is transmitting antenna B, the switch B1 is set to a low RF impedance, which is seen as a high RF impedance at the antenna port of antenna B. Therefore the signal from the RF part 12 enters the antenna B, and vice versa.

From FIGS. 5A, 5B, 6A, and 6B, it can be seen that Applicant's system enjoys an advantage of having only about 3.5 dB loss between the power amplifier and the antenna (2.5 dB for the tunable cavity and filter + 1 dB for each p-i-n diode switch). With a 5-dB improvement due to increased antenna gain (narrower beams), Applicant's system thus provides about 3 dB more emitted effective isotropic radiated power (EIRP) than an ordinary cellular system. Moreover, Applicant's invention enables, in addition to better C/I performance (i.e., about 5 dB better than a conventional system), frequency reuse 3 in most installations and the possibility of frequency reuse 1 in some installations, and 6 dB better sensitivity than conventional base stations.

Another significant advantage of Applicant's invention is that the transceivers can use single-carrier RF power amplifiers that are considerably more energy and space efficient than multi-carrier RF power amplifiers used in other systems. As noted above, the electrical efficiency of a single-carrier power amplifier can be a factor of ten greater than the electrical efficiency of a multi-carrier power amplifier, enabling an RBS to broadcast at higher power or with less electrical power consumption or with a combination of these.

It will be appreciated by those of ordinary skill in the art that this invention can be embodied in other specific forms without departing from its essential character. The embodiments described above should therefore be considered in all respects to be illustrative and not restrictive. The scope of Applicant's invention is determined by the following claims, and all modifications that fall within that scope are intended to be included therein.

WHAT IS CLAIMED IS:

1. A radio transceiver station, comprising:

an antenna system having a plurality of beams;

a plurality of radio transmitters, each radio transmitter including a base band part and a radio frequency part having a single-carrier radio frequency power amplifier;

a plurality of filters that are respectively connected to the plurality of radio transmitters and that are tunable to respective carrier signals generated by respective radio transmitters; and

a switch matrix for connecting selected ones of the filters to the antenna system such that carrier signals generated by the transmitters and amplified by the single-carrier radio frequency power amplifiers can be radiated through selected beams;

whereby each transceiver can be connected to each antenna beam independently of each other transceiver.

2. The radio transceiver station of claim 1, wherein the selected filters are connected to the antenna system in response to switch control signals based on information elements in information signal frames to be transmitted.

3. The radio transceiver station of claim 1, wherein the tunable filters include at least one tunable resonant cavity.

4. The radio transceiver station of claim 1, further comprising a signal bus connected between the base band parts of the radio transmitters for selectively distributing information signal frames to the radio frequency parts of the radio transmitters.

5. The radio transceiver station of claim 1, wherein the switch matrix comprises a plurality of p-i-n diodes.

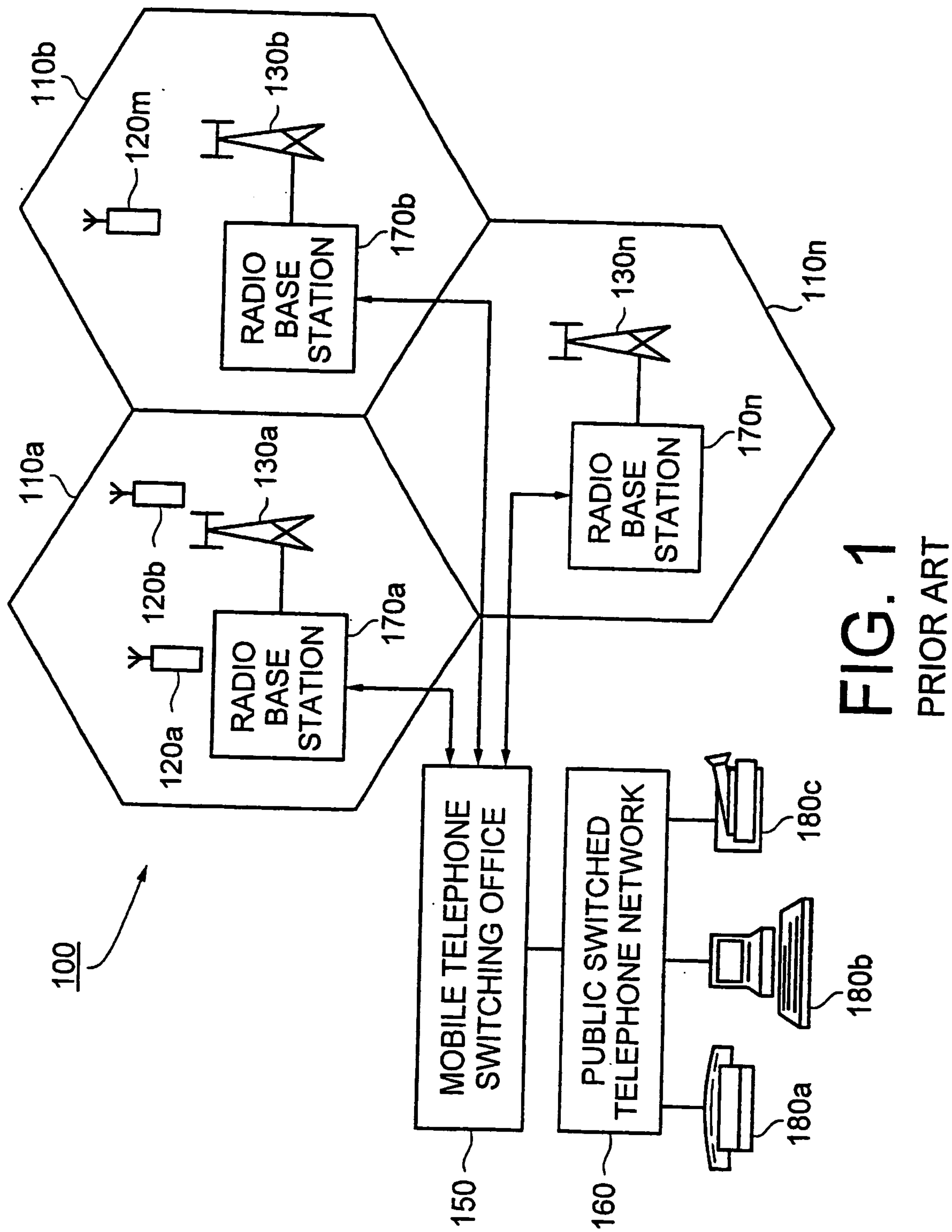


FIG. 1
PRIOR ART

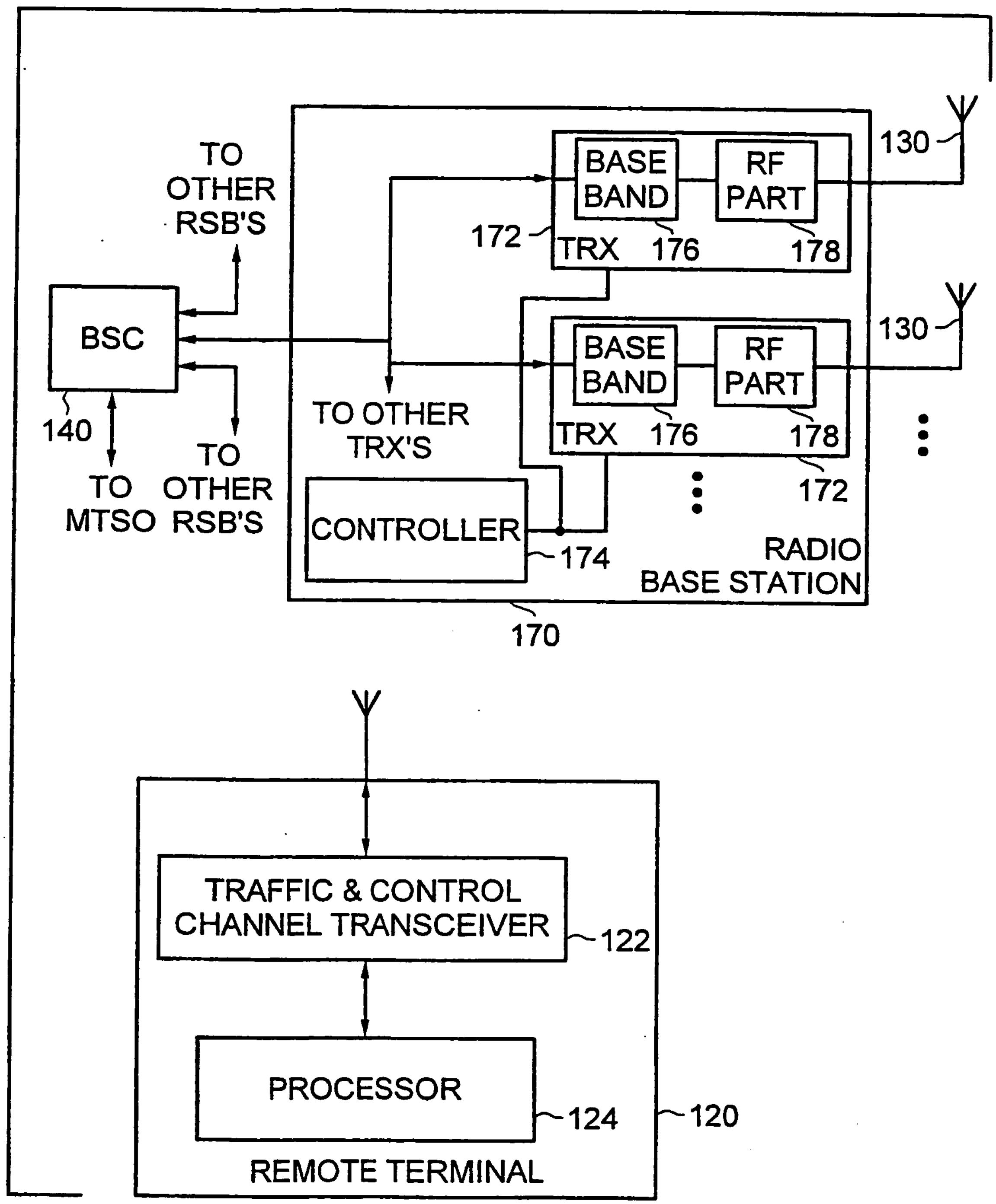


FIG. 2
PRIOR ART

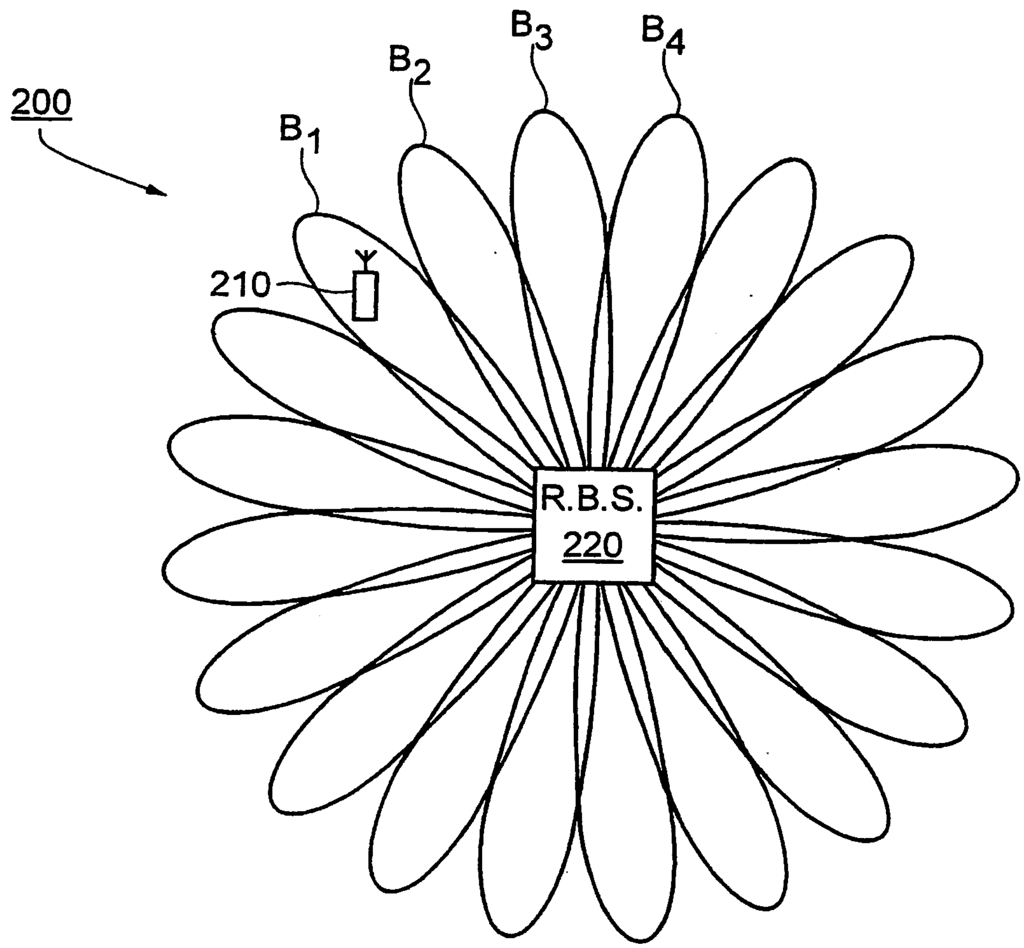


FIG. 3

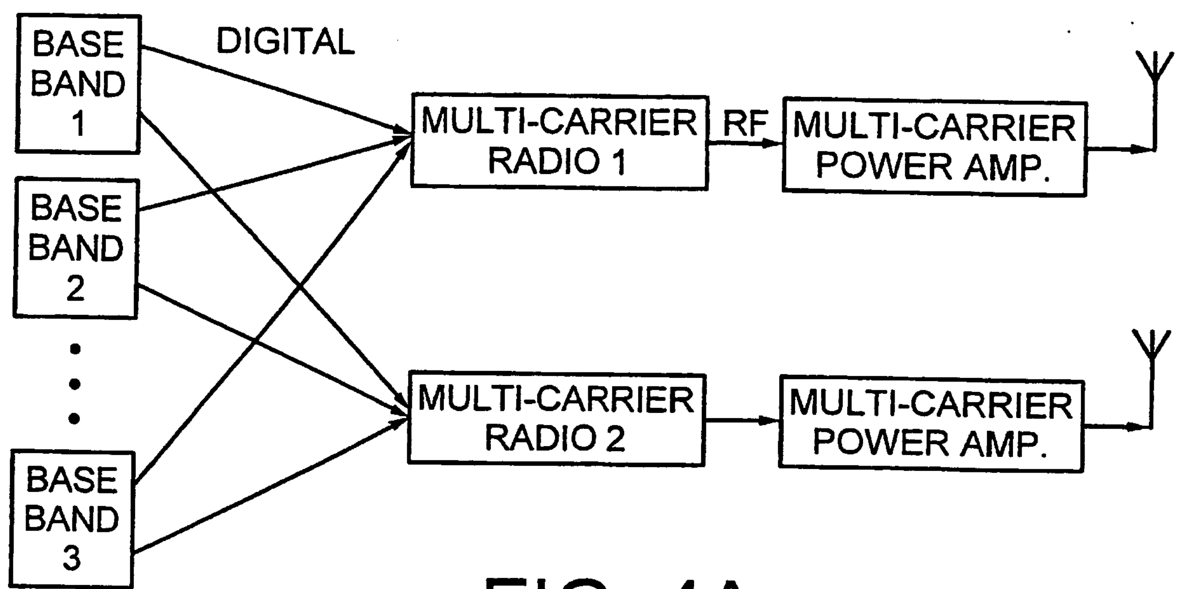


FIG. 4A
PRIOR ART

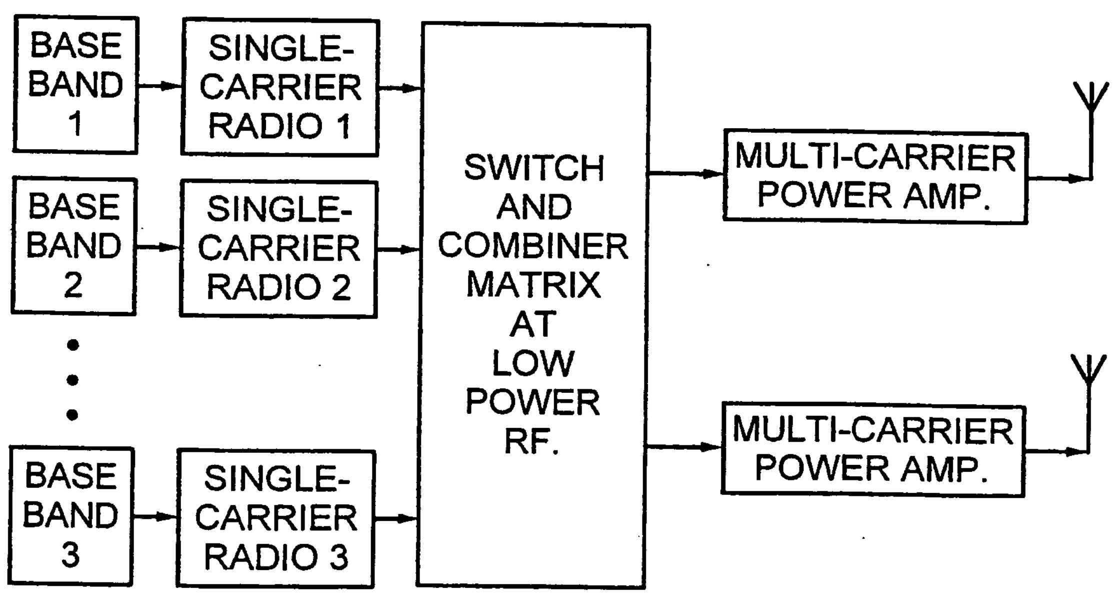
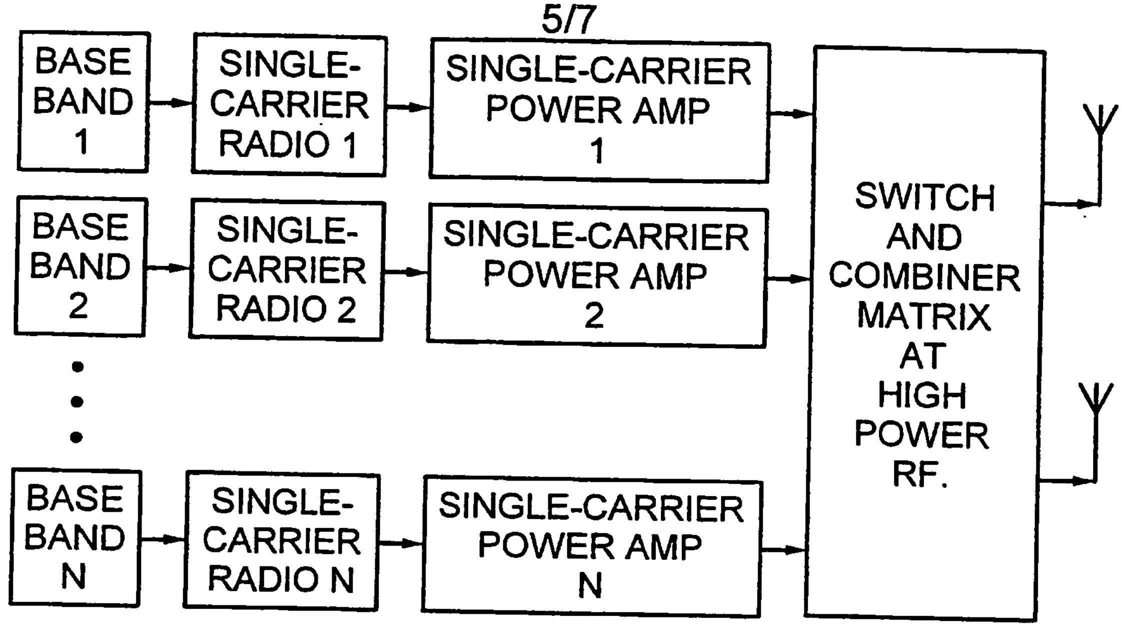


FIG. 4B
PRIOR ART


BASE BAND 1
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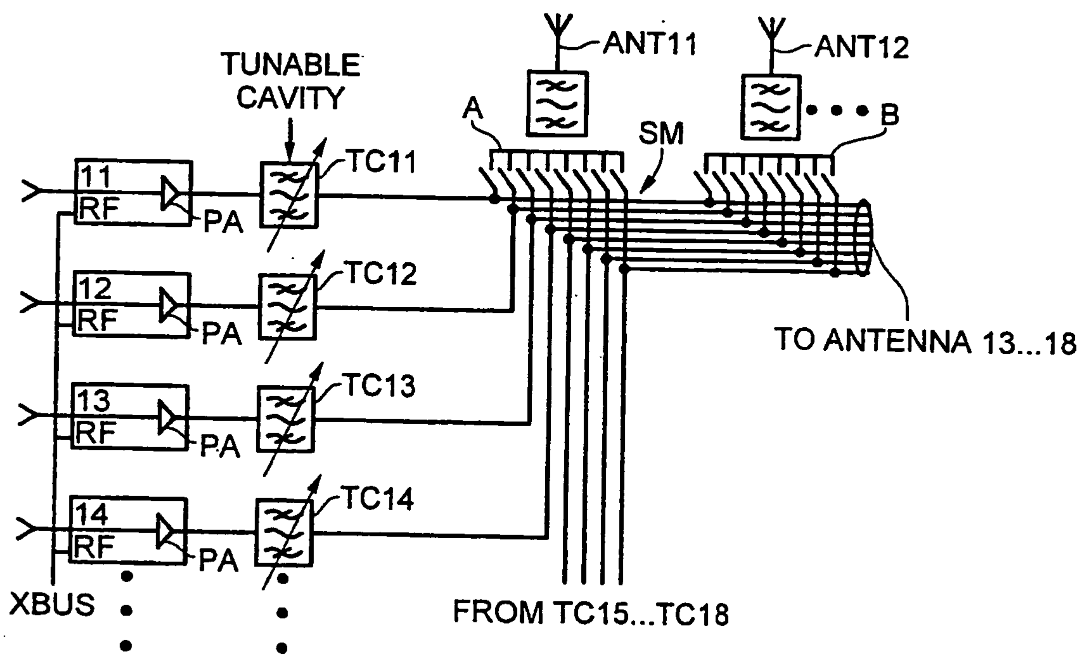
SINGLE-CARRIER POWER AMP 1
BASE BAND 2
SINGLE-CARRIER RADIO 2
SINGLE-CARRIER POWER AMP 2
BASE BAND N
SINGLE-CARRIER RADIO N
SINGLE-CARRIER POWER AMP N
SWITCH AND COMBINER MATRIX AT HIGH POWER RF.

FIG. 5A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TC13
14
RF
PA
TC14
XBUS
TO ANTENNA 13...18
FROM TC15...TC18

FIG. 5B

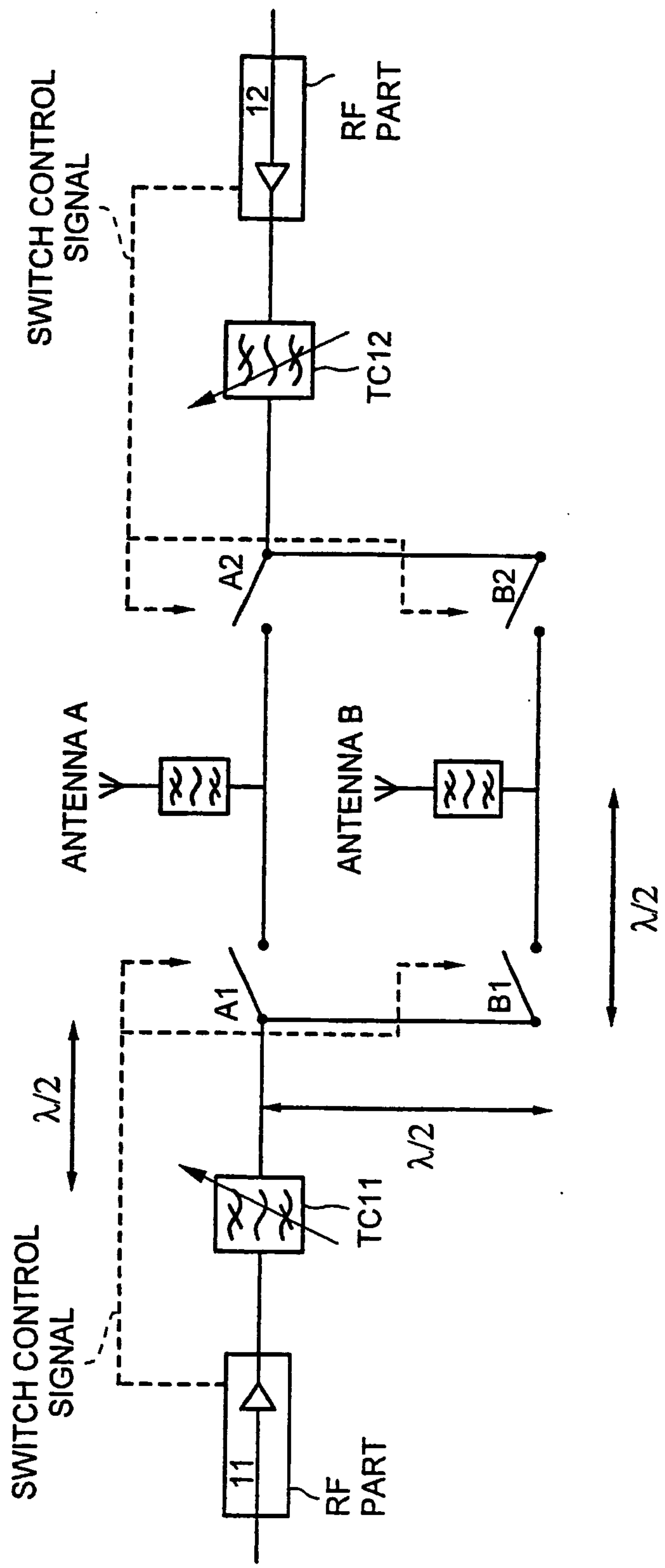
SWITCH CONTROL SIGNAL
12
RF PART
TC12
A2
B2
ANTENNA A
ANTENNA B
λ/2
A1
B1
λ/2
λ/2
TC11
SWITCH CONTROL SIGNAL
11
RF PART

FIG. 6A

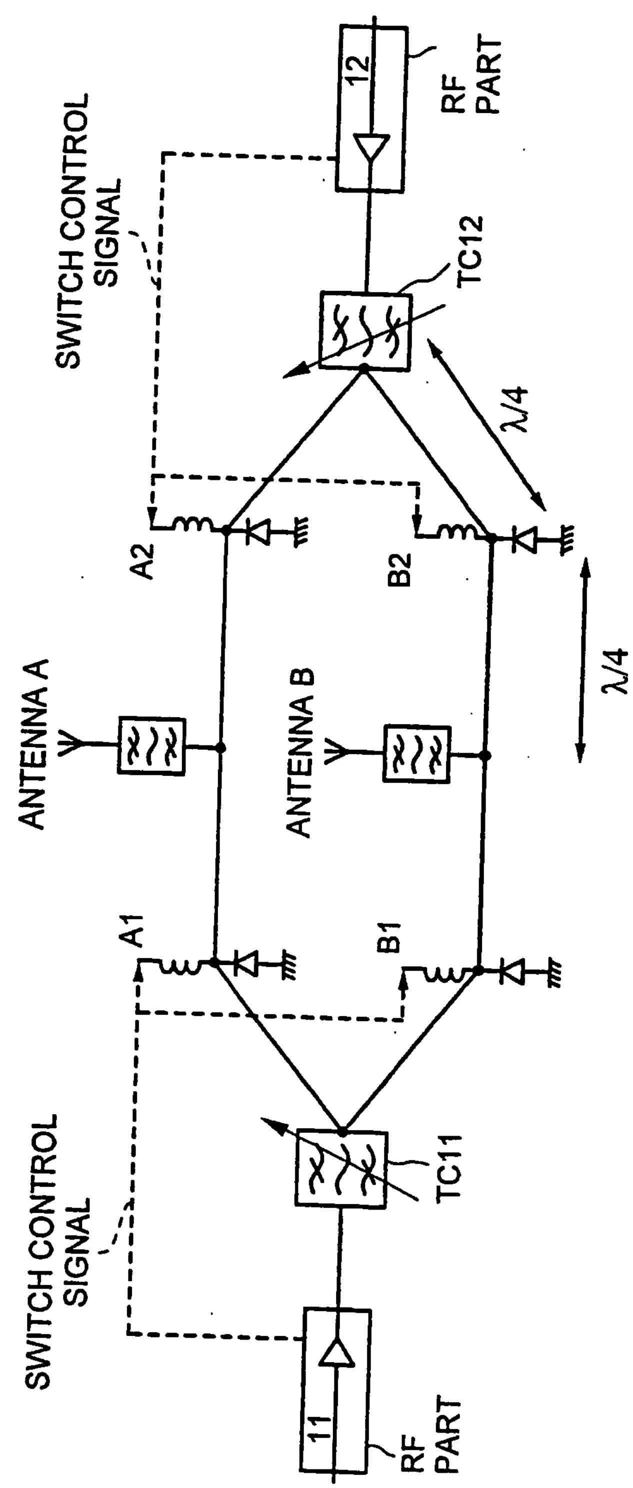
RF PART
12
SWITCH CONTROL SIGNAL
TC12
λ/4
A2
B2
ANTENNA A
ANTENNA B
λ/4
A1
B1
SWITCH CONTROL SIGNAL
TC11
11
RF PART

FIG. 6B

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/02347

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/04 H01Q3/24 H01Q25/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 399 206 A (MOTOROLA INC) 28 November 1990 (1990-11-28) * abstract * column 2, line 30 -column 3, line 2 column 3, line 24 -column 4, line 3 figure 1	1-3
A	EP 0 439 939 A (AMERICAN TELEPHONE & TELEGRAPH) 7 August 1991 (1991-08-07) cited in the application * abstract * column 1, line 32 -column 2, line 9 figures 1,2,4	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2000	25/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	López Márquez, T

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International Application No
PCT/SE 99/02347

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 593 822 A (NORTHERN TELECOM LTD) 27 April 1994 (1994-04-27) cited in the application * abstract * column 3, line 7 - line 26 column 5, line 35 - line 41 figure 4	1
A	EP 0 639 035 A (NORTHERN TELECOM LTD) 15 February 1995 (1995-02-15) * abstract * column 3, line 47 -column 5, line 12 claim 1; figure 6	1

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